We Claim:

1. A method of enlarging a transverse dimension of a waveguide written into a substrate by femtosecond laser pulses comprising the steps of:

producing a beam comprising a succession of pulses having pulse durations less than 150 femtoseconds and central wavelengths longer than an absorption edge of the substrate;

focusing the beam within the substrate to a spot focus at an intensity that produces an index change in the substrate at the spot focus;

relatively moving the substrate with respect to the spot focus of the beam along a first track of relative motion for producing a waveguide within the substrate, the waveguide having a longitudinal dimension along the first track of relative motion and a transverse dimension normal to the first track of relative motion; and

further relatively moving the substrate with respect to the spot focus of the beam adjacent to the first track of relative motion for enlarging the transverse dimension of the waveguide within the substrate.

2. The method of claim 1 in which the step of further relatively moving includes relatively moving the substrate with respect to the spot focus along a second track of relative motion adjacent to the first track.

3. The method of claim 2 in which an index change produced by the relative motion along the first track is substantially independent of an index change produced by the relative motion along the second track.

4. The method of claim 2 in which the second track along which the substrate and the spot focus are relatively moved is substantially parallel to the first track.

5. The method of claim 3 in which the second track of relative motion is one of a plurality of tracks of relative motion along which the substrate and the spot focus are relatively moved substantially parallel to the first track.

6. The method of claim 5 in which the plurality of tracks of relative motion are regularly spaced apart from each other.

7. The method of claim 6 in which the plurality of tracks intersect a transverse plane normal to a direction of the relative motion as vertices of a regular polygon.

8. The method of claim 1 in which the relative motion along the first track and the further relative motion adjacent to the first track are simultaneously imparted as components of a combined relative motion of the substrate and the spot focus.

9. The method of claim 8 in which the step of further relatively moving includes superimposing an instantaneous velocity component normal to the direction of the relative motion of the substrate and the spot focus along the first track.

10. The method of claim 9 in which the combined relative motion of the substrate and the spot focus produces a transverse shape of the waveguide that differs from a transverse shape of the spot focus.

11. The method of claim 10 in which the transverse shape of the waveguide produced by the combined relative motion is more elliptical than the transverse shape of the spot focus.

12. The method of claim 10 in which the transverse shape of the waveguide produced by the combined relative motion is less elliptical than the transverse shape of the spot focus.

13. The method of claim 9 in which the instantaneous velocity component is generated by relative motion comparable to an instantaneous angular velocity along an axis offset from the spot focus and extending in the direction of the relative motion of the substrate and the spot focus along the first track.

14. The method of claim 9 in which the combined relative motion is a relative helical motion between the substrate and the spot focus.

15. The method of claim 8 in which the spot focus has a non-circular shape and the step of further relatively moving includes superimposing an instantaneous angular velocity along an axis intersecting the spot focus and extending in the direction of the relative motion of the substrate and the spot focus along the first track for forming a more circular transverse shape of the waveguide.

16. The method of claim 1 in which the further relative motion of the substrate with respect to the spot focus of the beam is varied as a function of longitudinal position of the spot focus along the first track.

17. The method of claim 16 in which the further relative motion varies the transverse dimension of the waveguide as a function of a change in the longitudinal dimension of the waveguide.

18. A waveguide written into a substrate by femtosecond laser pulses in accordance with the method of claim 1.

19. The waveguide of claim 18 in which the waveguide has a diameter substantially larger than the diameter of the spot focus used for producing the waveguide.

20. A method of enlarging a transverse area of an optical waveguide written by femtosecond laser pulses into a substrate comprising the steps of:

producing a pulsed laser beam having a wavelength beyond an absorption edge of the substrate and a pulse duration less than 150 femtoseconds (fs);

irradiating a spot within the substrate with the pulsed laser beam at an intensity sufficient to induce a localized refractive index change in the substrate;

relatively translating the substrate with respect to the spot of irradiation so that the spot of irradiation traces a first section of the optical waveguide in the substrate distinguished by a refractive index difference with respect to surrounding portions of the substrate;

further relatively translating the substrate with respect to the spot of irradiation so that the spot of irradiation traces a second section of the optical waveguide distinguished by a refractive index difference with respect to surrounding portions of the substrate; and

juxtaposing the first and second sections of the optical waveguide for enlarging the transverse area of the optical waveguide normal to a direction of the relative translation between the substrate and the spot of irradiation.

21. The method of claim 20 in which said steps of relatively and further relatively translating are sequential operations.

22. The method of claim 20 in which the step of further relatively translating includes further relatively translating the substrate with respect to the spot of irradiation a plurality of times so that the spot of irradiation traces more than two sections of the optical waveguide.

23. The method of claim 22 in which the sections of the optical waveguide extend substantially parallel to each other.

24. The method of claim 22 in which the sections at least partially converge to form a tapered waveguide.

25. The method of claim 22 in which focusing qualities associated with the spot of irradiation tracing one of the sections is not affected by index changes associated with tracing adjacent sections.

26. The method of claim 22 in which the sections are substantially contiguous so that the index change throughout the transverse area of the optical waveguide is substantially uninterrupted.

27. The method of claim 22 in which the sections are arranged as vertices of a polygon.

28. The method of claim 22 in which the one of the sections is located at a center of the waveguide and other of the sections are located around a periphery of the waveguide.

29. The method of claim 28 in which the refractive index difference induced in the center section differs from the refractive index difference induced in the peripheral sections for adjusting a refractive index profile of the waveguide.

30. A waveguide written by femtosecond laser pulses into a substrate in accordance with the method of claim 20.

31. A waveguide written by femtosecond laser pulses into a substrate in accordance with the method of claim 29 in which the waveguide has a refractive index profile in which the refractive index difference induced in the center section differs from the refractive index difference induced in the peripheral sections of the waveguide.

32. A method of varying a transverse area of a waveguide written into a substrate using femtosecond laser pulses comprising the steps of:

producing a pulsed laser beam having a wavelength beyond an absorption edge of the substrate and a pulse duration less than 150 femtoseconds (fs);

irradiating a spot within the substrate with the pulsed laser beam at an intensity sufficient to induce a localized refractive index change in the substrate;

relatively moving the substrate with respect to the spot of irradiation for producing the waveguide within the substrate;

the relative motion including a first component enlarging a longitudinal dimension of the waveguide corresponding to an intended direction of light propagation along the waveguide; and

the relative motion including a second component enlarging a transverse dimension of the waveguide normal to the intended direction of light propagation along the waveguide.

33. The method of claim 32 in which the second component of the relative motion undergoes a periodic change in direction.

34. The method of claim 33 in which the second component of the relative motion is subject to rotation.

35. The method of claim 34 in which the relative motion is a helical motion between the substrate and the spot of irradiation.

36. The method of claim 32 in which the first and second components of the relative motion are orthogonal components.

37. The method of claim 36 in which the first component of the relative motion is subject to a linear velocity and the second component of the relative motion is subject to an angular velocity.

38. The method of claim 36 in which the second component of the relative motion is varied as a function of a change in the longitudinal dimension of the waveguide to vary the transverse area of the waveguide with respect to the longitudinal dimension of the waveguide.

39. A waveguide written into a substrate using femtosecond laser pulses according to the method of claim 32.

40. A waveguide written into a substrate using femtosecond laser pulses according to the method of claim 38 in which the transverse area of the waveguide is tapered in the longitudinal dimension of the waveguide.

41. A method of writing an optical waveguide in a substrate using femtosecond laser pulses comprising the steps of:

producing a plurality of pulsed laser beams, each having a wavelength beyond an absorption edge of the substrate and a pulse duration less than 150 femtoseconds (fs);

irradiating a plurality of adjacent spots within the substrate with the plurality of pulsed laser beams at intensities sufficient to induce localized refractive index changes in the substrate; and

relatively translating the substrate with respect to the plurality of adjacent spots tracing a waveguide in the substrate having a longitudinal dimension in the direction of translation and a transverse area filled by the plurality of adjacent spots.

42. The method of claim 41 in which the plurality of pulsed laser beams are produced by a common source.

43. The method of claim 41 in which the adjacent spots are evenly distributed within the transverse area of the waveguide.

44. The method of claim 41 in which the adjacent spots produce a waveguide having a radially symmetric refractive index profile.

45. The method of claim 41 in which the adjacent spots are arranged to fill a circular transverse area of the waveguide.

46. The method of claim 41 including the further step of varying performance characteristics between the beams.

47. The method of claim 46 in which focusing characteristics are varied between the beams.

48. The method of claim 46 in which intensity characteristics are varied between the beams.